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DESIGN AND IMPLEMENTATION
OF A PERFORMANCE MEASUREMENT
SYSTEM IN THE CIVIL ENGINEERING
DESIGN SECTION: A CASE STUDY

THESIS

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AFIT/GEM/LSM/88S-19

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THESIS

Presented to the faculty of the
School of Systems and Logistics
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ABSTRACT

The design section is responsible for designing projects for completion by contract, overseeing designs done by architect-engineer firms or the Army Corps of Engineers (COE). The impact a design section has on an Air Force base is enormous. The programmed budget for construction for 1987 was over $3 billion, or about 15 percent of the Air Force operations and maintenance budget.

Performance is important in any organization with this large of an impact. That performance should constantly be improved. Before performance can be improved it must be accurately measured. The literature available suggests that to accurately measure the performance of engineers, one must first identify key dimensions of performance which, when accomplished, will assure effectiveness. After effectiveness has been assured, then efficiency, productivity and quality need to be measured. Together these four things give a picture of performance.

A case study of an Air Force Civil Engineering design section was done with the purpose of documenting the system used for performance measurement. The system used measured effectiveness, performance against schedule,

efficiency and productivity. Some capability of assuring quality was also built into the management system.

The system that is used by the section under study does provide a limited capability to measure performance. However, this system uses mostly subjective measures and little actual quantifiable data. This is a weakness if fine differences in performance need to be measured, as would be the case for a performance improvement system.

DESIGN AND IMPLEMENTATION OF A PERFORMANCE MEASUREMENT SYSTEM IN THE CIVIL ENGINEERING DESIGN SECTION: A CASE STUDY

I. Introduction

Background

"The mission of Air Force Civil Engineering (AFCE) is to provide the necessary assets and skilled personnel to prepare and sustain global installations as stationary platforms for the projection of aerospace power in peace and war" (8:IMC 83-2). The design section fits into the mission by designing projects for completion by contract, and overseeing designs done by architect-engineer (AE) firms or the Army Corps of Engineers (COE). In addition to design, there are additional duties as assigned. These duties can be best characterized as serving the function of staff engineers, for not only AFCE, but for the rest of the chain of command as well. The design section has a multitude of studies, reports, suggestions and programs to deal with at any one time.

"The base civil engineer manages or otherwise administers some 40 to 60 percent of most installations operations and maintenance (O&M) budget" (17:53). In addition, approximately 15 percent of the O&M budget for the Air Force goes through AFCE in the form of completed designs ready for contracting (35:ch A). The impact the design section has on the base is enormous. This impact can be either positive or negative. Each project completed affects both the work environment and the ability to perform the mission. Likewise, each needed project left out will hinder the accomplishment of the mission. The rest of AFCE also benefits from good designs, in that required maintenance is reduced.

Research Problem Statement

A performance measurement model needs to be developed and tested for the engineering design section. Although several attempts have been made, the results to date have not been totally successful. One way of approaching the problem of measuring performance in design would be to find a design section that had developed and used a performance measurement system on their own.

One such design section exists at Tinker Air Force Base (AFB), Oklahoma. This thesis investigated and evaluated the system of performance measurement that Tinker AFB's design section has been using.

Objectives

Primary Objective. The primary objective of this study was to investigate and document the performance measurement system in use in the design section at Tinker

AFB. This included documenting the development and implementation of the system as well as how it has actually been used. Part of this documentation included an investigation of the validity of the system. Finally, the system's effectiveness in improving performance was investigated.

Secondary Objective. The second objective was to compare the performance measurement system used in Tinker AFB's design section to the recommendations of the experts as presented in the literature review.

Scope

This study focused on documentation of the performance measurement system as used by the design section at Tinker AFB. This required an investigation into the recommendations of the experts about how a performance measurement system should be designed and used. However, this is not to say that a better system or an alternative proposal should be developed from the literature review. The literature review is only intended to provide a basis of comparison for the system to be studied.

Limitations

There are two sources of limitation that enter this thesis. First, the performance measurement system being studied was designed by, and for the use of, the management of the design section of Tinker AFB. Therefore, it may not fit the suggestions of the experts exactly. This was one of the areas of investigation.

Second, because this is a case study, the knowledge gained may not universally fit other design sections. The peculiarities of Tinker AFB's design section may make the model unusable or only partially usable by another design section.

<u>Methodology</u>

This thesis was performed in three parts: literature review, case study, and analysis. In the literature review basic background was gained. From this background a model for comparison was developed. This included not only the basic requirements of a measurement system but the development and implementation of a system, and specific work related to the AFCE design section that had been done by past researchers. This model became a point for comparison.

The second step was to actually perform the case study. A case study was used because, although several studies have focused on what could be done in AFCE, no studies have been done about what is presently being used in AFCE. This left a gap between the academic research and the existing systems used by design sections. One of the benefits of a case study is that it allows for more flexibility in data collection. This allows the researcher to mold the study to fit unexpected conditions that may be encountered in the field. This flexibility allowed the research to readily explore the existing measurement system. This was necessary because of the small amount of information available about the existing system. This made the use of any other research tool impractical.

Another good reason for the use of a case study is to document information that is unique or not previously available to researchers (37:18). The data under investigation fits this last category because it deals specifically with what exists in AFCE. As previously stated, several studies have been done about what was available for use, and several models have been developed. However, not much study has been done about what is in use. This study provides that unique information by documenting a system that is in use in AFCE. Another purpose of a case study is to generate hypotheses. This would be helpful in bridging the gap between what has been done academically and what exists in AFCE (37:18).

The case study focuses on three areas. First, the reason the measurement system was developed, and how it was developed, were determined. Second, the system itself was documented. This documentation focuses on the system organization and development and includes how it is actually used. Finally, this study determined how well the system has been able to meet the needs of the management of the organization.

The final step in this thesis was to compare the features of successful performance measurement models discussed in the literature review with the system used at Tinker AFB, as documented in the case study. This comparison focuses on the validity of the system under investigation. This includes technical validity, organizational validity and use. Technical validity refers to "measuring what the model purports to measure" (26:153). Rumsey (24:33) distinguishes between technical validity of the model and technical validity of the organizational model, which "is a function of such concepts as ease of measurement, selection of appropriate variables and reliability/validity of the underlying variables" (24:33). "Organizational validity refers to the acceptability of the model to organizational users" (26:153). The final test was how well the model was used to improve performance.

To summarize, this thesis investigated the performance measurement system in use at Tinker AFB and compared it to the recommendations of the literature available. The comparison focused specifically on the validity of the system. Recommendations were made about how the validity and usefulness of the system can be improved.

Justification

There are at least three good reasons to test the model in use at Tinker AFB. The first reason is the need to improve performance. This need drives us to measure performance. The second reason is that AFCE has no proven successful model of performance for the design section. The only way to get a successful model is to keep trying. Since Tinker AFB already has a model, it only stands to reason that it should be evaluated. This will also provide future researchers information which might allow them to bridge the gap between what was done at Tinker AFB and what is recommended by the literature.

The last reason to test this model is that it is part of a design schedule program developed at Tinker AFB for the Wang computer and the work information management (WIMs) software. This computer system is in the process of being installed at every major Air Force base in the continental United States. This design schedule program is already in the process of being distributed and implemented at other bases, because developing a design schedule seems to have been a high priority and a difficult task for AFCE design sections for many years. If this program gains acceptance and recognition at those other bases it could be implemented throughout AFCE as part of the WIMs software for the Wang computer system. If the performance measurement part of this program is good, it should be implemented at other bases. If the performance measurement part of this program is technically incorrect, it should be remedied.

The possibility exists that this research could bring forth a usable system of performance measurement for the design section. Such a system could greatly benefit Air Force Civil Engineering.

II. Literature Review

Introduction

The literature review was intended to explore, develop and explain what a performance improvement program is and can be. This review starts on a very broad base, explaining the importance of performance and productivity. The next step is to present the basics of a performance improvement program. This explanation will include the need for improvement, definitions, program effectiveness, source of improvements, measurement system development and design,and validity.

Finally the literature review explains specific aspects of public sector, Air Force, white collar, and engineering productivity. This effectively breaks the literature review into two parts: mechanics and people. Both of these aspects are presented starting with the broad case and moving to the more narrow focus.

Need for Improvement

"The failure of U.S. productivity to keep up with the Japanese and the rest of the world's major industrialized nations is a growing national concern. Our national leaders have stated that the economic survival of our factories, our standard of living, and ultimately the survival of our economic, political, and governmental systems could be at stake" (10:653). Others differ slightly, saying, "The United States has been, and continues to be, the most productive nation in the world" (28:5). However, there are nations that are gaining fast. This gain by other nations translates to a relative decrease in our standard of living, and an increase in the gaining nations' standards (28:5). Either way, the experts agree that our nation's standard of living is at stake.

The Federal Government is concerned about its performance also. This stems not only from the national interest in productivity, but also from budgetary constraints. "At a time when we're looking for ways to reduce the government spending and curb the deficit, it only makes sense to encourage productivity which will save the taxpayer's money by making the government more efficient" (19:146). This was reflected when the President issued Executive Order 12552 on 25 February 1986. This order mandates a 20 percent increase in productivity by 1992. "The program has the twin goals of achieving substantial improvements in government efficiency and of changing the way managers manage--and thus makes it clear that managers must engage in systematic and continuing efforts to improve productivity" (9:252).

The need for improving the performance of the design section of Air Force Civil engineering (AFCE) is driven by at least two other major concerns to the United States Air Force. The first concern is centered around the mission of the design section, which is to design projects for new construction and renovation, for completion by contract or in house forces. The design section is constantly being tasked to do more, yet the design budget often does not increase enough to cover the task. By improving the performance of the design section, the mission of completing more projects on a restricted budget will be met more effectively. The demand for performance comes in a time of real budget decrease, while confronted with increased need (35:a-21). The design section's primary objective is to accomplish more with less.

The second concern is the national view that the federal government is not able to manage efficiently. Although little can be done to convince critics, a valid performance measurement system could be helpful in swaying the public's views, if it could "measurably demonstrate that the government is being efficiently managed" (9:253).

> In the November 1983 GAO (General Accounting Office) report entitled Increased Use of Productivity Management Can Help Control Government Costs, and in a subsequent article published in the spring 1984 National Productivity Review , Peter Lemonias and Brian Usilaner argue convincingly that seven key elements, culled from both public- and private-

sector practices are essential for an effective productivity effort. These elements are:

1. A manager serving as a focal point for productivity in the organization;
2. Top level support and commitment;
3. Written productivity objectives and goals and an organization wide productivity plan;
4. Productivity measures that are meaningful to the organization;
5. Use of the productivity plan and measurement system to hold managers accountable;
6. Awareness throughout the organization of productivity's importance and involvement of the employees in the productivity effort; and
7. An ongoing activity to regularly identify productivity problems and opportunities for improvement throughout the organization (9:254).

Buried in the middle of the above list is one of the things that makes performance improvement systems different from what managers did in the past: the performance measures. Without a performance measurement system, there is little or no way to tell how some management decision affected performance. After all, "you cannot manage what you cannot measure" (12:17). "Productivity measurement is an essential element of an effective productivity improvement effort. The measures need not be precise, total factor measures. Often, a series of measures that are easy to understand and calculate and that are meaningful to managers and employees is more useful" (19:147). Improved performance is one of the things that managers have been working to achieve since the beginning of scientific management. The improvement of performance relies on old and proven management principles.

The only real difference is that now instead of simply trying to manage, managers are becoming interested in directly managing performance. Before the implementation of productivity programs, productivity was an outcome of management, but the quest for productivity was far less organized.

Definitions

In much of the literature the word productivity and performance are not well defined. For instance, the terms performance and productivity are often used interchangeably. Performance is a more general term that does not carry with it the emotional appeal engendered by the term productivity. When discussing performance one must define the aspects of performance that are deemed most essential.

The general aspects of performance that are measured consist of quality, effectiveness, efficiency, quality of work life, innovation, and productivity. Some or all of these things may be important to the survival of an organization (28:41).

Quality. Quality is the degree to which the products produced conform to requirements, specifications, or expectations. Customer satisfaction is inherent in the idea of quality. Another aspect of quality is product performance; the product must meet the need for which it was produced.

Effectiveness. Effectiveness is the degree to which the organization accomplishes what it set out to accomplish. Measurement of effectiveness often relies on other aspects of performance, such as quality, quantity and timeliness.

Efficiency. Efficiency is the ratio of the resources expected to be consumed to the resources actually consumed. This definition of efficiency rests on estimates or expectations which form the baseline for comparison.

Quality of work life. Quality of work life is the way employees respond to sociotechnical aspects of the organization. This is reflected in absenteeism, employee turnover, and other employee behaviors.

Innovation. Innovation is applied creativity. Innovation is how well the organization develops and implements new and better ideas, as measured in the relative features of the products produced.

Productivity. Productivity is the ratio of the quantities of output to the quantities of input. Productivity is different from efficiency in that it is not based on any estimates.

Program Effectiveness

How effective are performance management systems? Case studies are available of public sector and private sector systems. These studies show that each organization is different, and the improvements that are possible are also different. According to Lemonias and Usilaner, average performance improvements of about nine percent annually have been realized by the companies they interviewed, with state and local government improvements ranging from two to five percent (19:139).

In Calgary, Canada, the city engineers found incredible savings. "In the first year they had a $4 million surplus against an $18.5 million budget. Of this $4 million, one third could be attributed directly to improved productivity and lower unit costs..."(27:142).

The U.S. Copyright Office has implemented a productivity improvement system with excellent results. Over the last five years they have had "a 23 percent increase in work load along with a 19 percent decrease in staff while achieving a 15 percent increase in productivity" (23:155).

Stevens found that in an analysis of city government, "Appropriate changes in management practices can result in savings of up to or even greater than 50 percent" (31:398).

Sources of Improvement

Where does the added performance come from? It appears that performance improvements come from three areas: mechanical, organizational, and personnel. Mechanical improvements include any plant or equipment changes that cause the system to perform better. Organizational changes are those changes in the organizational structure that make the organization better capable of supporting the workers in their job performance. Personnel changes include a multitude of things such as changes in work methods, rules, regulations, or job assignment.

The sources for these changes can come from the workers and a more participative approach to management, or from one of a multitude of formal methods of analysis. The participative approach usually starts when an organization begins a performance improvement system. The first step is often to implement a measurement system. This requires management to evaluate the reasons for being in business. The mission usually comes into focus. A multitude of activities are identified as not being mission essential.

A specific, formal method of identifying what is and is not important is organizational analysis (36:171) or organization function analysis (OFA) (5). Both of these methods are very similar OFA will be outlined here because a more in-depth presentation is available.

The first step in the OAF process is to secure the total commitment of upper management (5:ch 9). For this system to really work upper management must demonstrate a real willingness to change, to challenge traditional practices and lead others to do the same. This starts with a senior management training program that usually takes a full day. Another day is then devoted to program planning. This planning includes objectives, scope, participation, schedule, and the method of communication to be used. The program should be as broad as practical and designed for long-term change. Short term perceptions should be eliminated, because they will limit the program too much.

The first step in determining the scope is to determine what functions should be involved. After the program scope is determined, the OFA team can be selected. Volunteers should not be accepted. Team members should be solicited from the functions involved, not to be representatives, but to add breadth of knowledge. Different experience levels should also be included: the very new, and the very experienced. Team members should be respected by management and their own peers. The last, and possibly most important, criteria is attitude. The members selected must have a constructive attitude, and a genuine desire to work with others to improve productivity. The size of the team will vary, but for a typical AFCE squadron of about 550 people, a team of about 20 members should be selected.

The next step is to train the team. This should include 20 to 30 hours of formal instruction in OFA. Good training is absolutely vital to the success of any participative management program. After the team is trained, a plan must be developed for information gathering. This plan should be specific enough to include who will actually be interviewed. The people that perform each operation in the work place should be interviewed. The purpose is to gather information about what actually takes place, rather than what the manual or the supervisor says is supposed to happen.

The team will then divide the interviews down into areas of work similarity, called modules. Then the OFA team will form two-man groups; each group will take one module. The interviews should determine quantitative and qualitative data about the job. The quantitative data should include demand volumes, hours of effort involved per month, cycle times, and expenses. The qualitative data should include specific observations, suggestions and recommendations.

The next phase is information analysis (5:ch 10). During this phase there are three key functions. The first function is to maintain the master list of definitions of functions, demands, and demand volumes. These lists are updated constantly as data is analyzed.

The second key function is to coordinate and maintain analysis summary sheets. This is the final collection of quantitative knowledge. First, all of the data gathered is transferred onto operation summary sheets. These sheets briefly tell who does what, why they do it, how often, and how long it takes. The operation summary sheets then are used as source information to fill out the function summary sheets. These sheets tally all of the information about any given function. The last step is to fill out OFA ratio summary sheets. These sheets give all of the pertinent data about each given function.

The third part of OFA is taking the key observations that were made during the information gathering and processing stages, condensing the observations into one line statements and sorting them by function. Finally a function flow diagram is developed. This diagram shows how work actually flows in the organization.

The next step is evaluation and improvement identification (5:ch 11). In this step the team tries to evaluate the information and determine what it really means. The team then develops solutions and methods of improvement. This is done by starting with each demand the organization faces, and then each function that answers that demand, and then each operation. In all of these steps, the same type of questions are asked:

1. Is the demand valid and what effect does it have?
2. Is there a better way of doing it?
3. Can we reorganize to better meet these needs?

After the analysis has been done, the recommendations are gathered into a report and forwarded to top management. These recommendations are then modified as necessary, and a plan for implementation is developed.

Some other methods are less formal: Bolte recommended a similar approach to essential task identification. He recommended that managers ask in relation to each activity, "Should this task be done at all?" (3:136). If the answer isn't adequate, the activity is eliminated. The other part of this process, Bolte suggests, includes getting the right person to accomplish the right job. In addition, areas that need other improvements usually surface at this time. Rules need changed. Equipment needs replaced, or purchased.

In addition to the benefits received from using improved work techniques, the individual performance of employees may improve. A sense of competition may promote this improvement, or in the private sector, monetary incentives are often used. Another possibility that was not mentioned by any of the authors, is the "Hawthorne effect"

(6:209), in which workers improve performance simply because they are being watched.

Performance improvement comes from both improved methods of work and improved employee performance. Sheehy concluded that "the potential for improvement (in performance) tends to increase exponentially the further from the shop floor and into the management system one probes..."(27:144). There are great possibilities for improvement and the possibilities increase the further up the chain of command they are implemented. However, before performance improvement can begin, commitment to improve performance must be obtained and measurement should start.

Types of Measurement Systems

Most measurement systems claim to, or say that they, measure specific areas of performance. However, because of the weak definitions incorporated, the systems often include many performance measures.

Sink describes productivity measures as ratios of output over input. He further breaks these ratios into two broad categories based on the type and quantity of measures used. The first category is whether the measure is static or dynamic. Static productivity ratios are simply output divided by input for some given period of time. Dynamic measures are basically static measures of one time frame divided by static measures from another time frame(28:26).

There are three types of productivity measure in each of the above categories; partial-factor, multi-factor, and total factor. Each of the measures is a ratio; however, the denominators (inputs) are different. In partial-factor analysis, only one input is used in the ratio. In multi-factor analysis more than one type of input is used and in total-factor analysis all of the system inputs are used (28:26).

Another important area is that of surrogate measures. Surrogate measures are taken from areas that are closely correlated with the types of measurements that are actually desired. These are usually used when direct measurements are unavailable. Surrogate measures are frequently used for white collar workers.

Sink recommends, for use at the level under study here, either the normative performance/productivity measurement method (NP/PMM) or the multi-criteria performance/ productivity measurement technique (MCP/PMT) (29:282). NP/PMM is mostly a method of developing performance/productivity measures using a structured group process such as the nominal group technique or the Delphi method. This assures the consensus of the workers. NP/PMM involves 5 stages.

Stage one involves structured group process generating a group of prioritized productivity measures, ratios and indicators. The reason for using a participative approach is to "ensure adequate motivation, commitment, and accountability on the part of key participants for implementation and acceptance of the resultant productivity measurement system" (29:275).

Stage two involves having a productivity analyst take the information from stage one and determine how to implement the measures suggested. The analyst also determines how and where to obtain the data. After the analyst works on the measures, the group helps shape them into a usable system.

Stage three involves briefing the management and workers about the system. These briefings invite comment and discussion. After the briefings any necessary modifications are made before the system is actually approved.

Stage four involves integrating the system with any existing management control systems, and actual implementation and use.

Stage five is continuous monitoring of the final system. This provides feedback for performance improvement as well as system modification. In addition, this lends credibility to the performance improvement program.

There are drawbacks to this method. Sink said, "However, difficulties in operationalizing measurement systems that have origins in a participative process hindered early efforts. The question of how to evaluate performance against a list of measures that is highly heterogeneous became critical to continued development. The MCP/PMT overcomes these difficulties" (28:276).

MCP/PMT is similar to NP/PMM, except that it adds a more structured approach to implementing the measures. This approach allows the aggregating of multiple, heterogeneous measures into a common output.

There are other very structured methods for developing productivity measures, most of which fit into one of Sink's broad categories. The methodology for generating efficiency and effectiveness measures (MGEEM), developed by the Air Force Human Resources Laboratory, is one of these systems and could be categorized as an MCP/PMT system. MGEEM is detailed enough to be used by nearly anyone with a good understanding of the organization to be measured. MGEEM starts by forming a group from the organization's upper management, who then use a group process to define the measurable facets of the mission of the organization under study. These goals, called key result areas (KRA's) are then passed to another group from middle management. This group then develops specific indicators, or areas to be measured. These measures are then implemented and feedback started. MGEEM also includes information on problem solving, risks, pitfalls, fears and some examples (33).

Another valuable tool for helping to develop a measurement system is to look at the organization with a systems approach. This can help develop measures by clarifying the inputs and outputs (18:32;34:213). All of these approaches involve the worker in choosing the items to be measured. Involving the worker is important to assuring organizational validity.

Measurement System Design Basics

Getting the employees involved in designing the measurement system may be the most important step in implementing a performance improvement system. If the employees are not convinced that the measurement system is valid, then no effort will really be successful in implementing that system. In addition to fostering organizational validity, getting the employees involved also causes them to focus on performance. This often causes them to improve their own performance and bring to attention hindrances to performance that exist in the system.

It appears, from the number of times mentioned in the literature by authors such as Sink, Lemonias and Usilaner, and, Bolte, that the three most important parts in the development of a performance measurement system are top management support, user acceptance, and simplicity of use. Top management support is essential or the people will simply not see the need to be involved in the program. This management support helps foster an organizational climate of performance improvement. Furthermore, if top management is not committed to productivity improvement and measurement, any time spent on system development will probably be wasted.

User acceptance can be fostered in many ways. Without user acceptance the system will never work well, because the system will inevitably require inputs from the employees. If the employees do not accept the system, those inputs may not be provided or may be inaccurate. In addition to simply accepting the measurement system, the users need to accept the idea of performance improvement.

Simplicity is a relative thing. The users need to be able to understand what is being measured and why. In addition, they need to understand the results, and how to affect changes in those results.

After a good performance measurement system is designed, the organization can start focusing on what can be done to improve performance. During the improvement stage, workers and managers are often given added training. This training may be a refresher in, or continuation of that training the organization normally gives, or it could be new techniques in management, or problem solving from some source outside of the organization.

Often, a management action team is formed to solve problems. If this is the case, these people are given special problem solving training, and training in analytical techniques (3:136).

The last step is follow-through. A performance improvement system needs constant monitoring in order to provide management the inputs necessary to keep performance improving. If the system is not maintained and used, it is useless.

Public Sector Productivity

The general public opinion of the government is that it is not as efficient as it should be (9:253). Almost everyone agrees that part of the reason is that the government has too much red tape. In many ways, it appears that government in general, and the federal government specifically, needs performance improvement programs to keep from stagnating and becoming too encumbered with excess rules and regulations.

In the private sector the inefficient companies go out of business. If a company becomes unproductive, it probably will be warned when the profits go down. If that company fails to react in a timely and appropriate manner, then its early demise is nearly assured. Government has no simple items like profit, or products produced per man-hour, to watch. In the private sector companies are in direct competition with each other. This competition is often lacking in the federal government (22:14). Instead, it would appear that other methods must be developed to provide the same type of information. One could gauge how the federal government is doing by how much one gets compared to how much tax one pays. But that would give too many opinions that are dependent on too many factors. So the government, unlike private industry, finds itself without a convenient method of determining organizational performance. This can be remedied with a performance improvement system.

Often an organization could reap great benefits from just designing a performance measurement system, even if it were never implemented. Because, when a performance measurement system is designed, it causes people to look at priorities and management basics. This design process causes management to identify unnecessary work. When the system is implemented and people start looking past the obvious for ways to improve, then less obvious inefficiencies start to be identified. This process is necessary in any organization, but even more so in an organization as prone to picking up excess rules and procedures as the federal government. Once the system of productivity measurement is in place, and the major problems have been worked out, people can continue to search for areas to improve. The engineering department of the city of Calgary, Canada, found that this search for improvement can go all the way to the "very bedrock of the organizational structure" (27:144).

Once all the problems have been worked out, it is expected that competition with other organizations, or past history, will keep the inefficiencies from building back up. However, this has never been shown, because no one has ever really gotten all the way to the end. Nor does this author believe the end will ever be reached, because this is a process that needs to continue. Once the performance improvement system is in place and has the support it needs, then it becomes a perpetual self cleaning process (9:256). Removing unnecessary hindrances and regulations is a process that is vital and necessary for any organization to survive, and thrive, especially government.

USAF Productivity Programs

The United States Air Force has at least two major programs on productivity improvement. One that has already been mentioned is MGEEM, and it is available as a resource upon request (33). Another, used by the Tactical Air

Command (TAC) is the PEER competition (30).

MGEEM specializes in unique individual development of performance measurement systems. It includes a series of pamphlets that aid in the development of such systems using a modified MCP/PMT as described earlier. This has been especially developed to take care of some of the unique problems encountered in the USAF (33).

The PEER competition used by TAC is something that an outside contractor was hired to develop. The contractor produced a few performance measures for each organization on base. Each base in TAC is rated using these measures. Between 1978 and 1984 TAC improved the sortie rate and in service aircraft rate by 80 percent. General Creech, then Commander of TAC, attributed that improvement to eliminating performance barriers by decentralization, and to competition between units (22:14). Brigadier General Roy M. Goodwin, Deputy Chief of Staff for Engineering and Services for TAC, said that two-thirds of the indicators presently being measured are increasing. The bases that have consistently poor performance on any one of the indicators get looked at carefully, and usually have some problem that gets solved because of this attention. In this way the PEERS competition allows the command structure to identify problem areas, and also to highlight strengths (11).

Baumgartel and Johnson attempted to measure the performance of base-level AFCE, based on goal attainment. A model was developed using inputs and outputs available in the base engineering automated management system (BEAMS) and the command update. However, they found that more research would need to be done to get output measures to reflect goal attainment, because, although specific input data was available, the same was not true of the output data (2). The output data could not be tied directly to one specific goal. This model identified seven main goals for the engineering and environmental planning branch, with 18 sub-goals. They noted that, in most cases, the goals were not specific enough to allow direct measurement. The goals identified for the Engineering and Environmental Planning Branch include the following (2:81-83):

Goal #1--Facility Life Cycle Cost

A. Identify and program MCP projects, and monitor approval, design and construction phases to ensure maximum durability and maintainability of accepted facilities.

B. Ensure in-house design complies with AFM 88-15 and applicable building codes.

Goal #2--Facility Function

A. Ensure new construction projects are identified and programmed in a timely manner, and are designed and located in accordance with the user's requirements.

B. Identify and program contract corrections to facilities which are functionally inadequate for mission requirements.

Goal #3--Facility Protection

A. Ensure corrective contract actions for identified facility fire, safety, and security deficiencies are programmed, designed, and completed in a timely manner.

B. Ensure new contract work complies with regional requirements for structural protection against weather and earthquake-related forces.

Goal #4--Utility and Energy Supply and Conservation

A. Complete engineering analyses of existing and programmed utility supply and distribution systems to identify inadequate supply or inefficient operations.

B. Ensure new facilities are designed and constructed to minimize energy consumption.

C. Complete engineering analyses of existing facilities to identify sources of energy waste, and program projects to correct deficiencies identified.

Goal #5--Environmental Protection and Conservation

A. Ensure facility projects are assessed for adverse environmental impact prior to programming.

B. Include environmental impact considerations during master planning actions, to minimize adverse impact due to siting.

C. Ensure control, handling and disposal of hazardous substances and waste products comply with EPA standards.

D. Ensure that construction practices comply with EPA standards.

Goal #6--Facility Occupant/User Requirements

A. Complete architectural studies of facilities to identify inadequate aesthetic conditions and facility deficiencies contributing to occupant discomfort.

B. Ensure designed projects comply with applicable life safety and public health code requirements.

C. Ensure identified facility life safety and health code deficiencies requiring contract corrective action are programmed, designed, and completed in a timely manner.

D. Identify, program and specify custodial contracts required for base facilities and ensure contractor compliance with the contractual requirements.

Goal #7--Other Non-facility Requirements

A. Provide professional architectural and engineering assistance to operations branch and to other organizations as required.

Kaneda and Wallet extended the research done by Baumgartel and Johnson, and developed ratios to be measured. These ratios were tested by survey to determine their usefulness. Six of the ratios were determined to be useful in measuring performance in the design section. In addition, the survey results revealed that although AFCE managers saw the need to measure performance, they were opposed to the idea of an imposed system. AFCE managers made it clear from the results that they wanted any measurement to stay at the organizational level. The system needed to be flexible so that it could be tailored to individual needs. Kaneda and Wallett also warned that comparing design sections would not be advisable and that the productivity measures "... must be a means to improve management rather than ends in themselves" (17:78). The ratios developed were (17:63):

Total estimated dollar amount of contract projects and in-house work orders designed divided by total design man-hours.

Total number of projects designed (complete and ready for acquisition action) divided by total design man-hours.

Total number of facility inspections and utility system surveys completed divided by total man-hours to complete surveys and inspections.

Total estimated dollar amount of AE design acquisition packages prepared divided by the total man-hours to prepare.

Total estimated dollar amount of contract projects and in-house work orders designed divided by total design labor cost.

Total number of projects designed (complete and ready for acquisition action) divided by total design labor cost.

Astin and Ruff developed a model to compare one design section with another using constrained facet analysis (CFA) (1). "Constrained Facet Analysis is a linear programming model designed to evaluate the relative productivity-- or efficiency-- of a number of organizations which are all producing different combinations of outputs using different combinations of the same inputs. It is theoretically attractive because it accomplishes the determination of the relative efficiency of organizations with no need for a priori evaluations of the relative weights or values of the various resources consumed and outputs produced. The model determines these efficiencies based solely on the actual data representing the input and output quantities" (24:1). This model used six input measures and 20 output measures based on some of the work of Kaneda and Wallet. This model only tested CFA's ability to distinguish the high performance sections from others with lesser performance. Astin and Ruff's model successfully showed that CFA could distinguish performance differences as expected. The measures developed are as follows (1:39-41):

INPUTS

1. Labor man-hours.
2. Labor costs.
3. Years experience.
4. Personnel skill level aggregate.
5. Number of professional education courses completed.
6. One over the number of additional duties performed.

OUTPUTS

1. Total contract funds obligated.
2. Estimated dollar amount of all projects designed.
3. Total O&M maintenance and repair project funds obligated.
4. Total O&M minor construction funds obligated.
5. Total number of projects designed.
6. Total number of facility inspections and surveys completed.
7. Total number of special technical studies and reports completed.
8. One over the total funds expensed on contract change orders.
9. One over the number of contract change orders.
10. Total estimated dollar amount of in-house work orders designed.
11. Total estimated dollar amount of architect-engineer packages prepared.
12. Total A-E funds obligated.
13. Estimated dollar amount of MCP project books.
14. Number of work orders reviewed and/or evaluated.
15. Number of technical reviews accomplished on designed projects.
16. Pages of project specifications.
17. Total number of oral presentations made.
18. Number of facility surveys completed.
19. Total hours of surveys completed.
20. Number of pages of engineering drawings completed.

In a dissertation in 1986, Rumsey developed and tested the technical validity of a similar model using CFA. However, he found that the results were less than favorable (24). The measures Rumsey used were the following (24:69):

INPUTS

1. Military engineers assigned.
2. Civilian engineers assigned.
3. Other military assigned.
4. Other civilians assigned.
5. Total years experience.
6. Personnel skill level.

OUTPUTS

1. Total contract funds obligated.
2. Estimated value of project designs completed.
3. Total O&M maintenance and repair project funds obligated.
4. Total number of design projects completed.
5. Total cost of contract change orders.
6. Total number of contract change orders designed during this period.
7. Total estimated dollar amount of in-house work orders designed during this period.
8. Estimated value of architect-engineer packages completed during this period.
9. Estimated value of MCP project books completed during this period.
10. Number of work orders reviewed.
11. Number of technical reviews completed on design projects.

White Collar Productivity

Bumbarger takes exception to the use of the term white collar; he prefers to look at the amount of knowledge work done by the worker (5:5). For this work, white collar workers will be simply defined as those who do almost entirely knowledge work.

Some claim white collar productivity cannot be measured (4:47). Bolte said that this is not true. "All administrative areas produce a specific end product or service that can be measured" (4:47). The question is one of accuracy, and willingness to expend the necessary effort to develop a method of measure.

It is true, however, that the measurement of white collar productivity is not nearly as straight forward as blue collar productivity. One of the problems for white collar areas is that "statistical techniques commonly used by industrial engineering or in quality circles require quantitative data, which is not easily developed in professional or administrative positions" (13:288). Kinlaw concluded "it is also apparent that development of models and technical descriptions of measures for complex white collar organizations (e.g., scientific and engineering) is still in the formative stage" (18:30).

One of the problems is that white collar workers generally have more than one output, and the outputs often compete directly for organizational resource. Generally, the problem is that the inputs and outputs are not as readily recognized. Yet, with some work, that too can be overcome and is addressed specifically by many of the measurement system development techniques like MGEEM.

One of the ways of defining input and outputs is to look at the organization with a systems perspective. By defining boundaries around the system, recognition of inputs and outputs becomes easier. Inputs and outputs have to actually cross the boundaries.

Tuttle and Romanowski divided white collar workers into two groups, direct outcome and indirect outcome. "In a direct outcome system, there is a direct, high probability relationship between the output and the outcome" (34:214). Clerks might fit in the direct outcome category; however, engineers fit in the indirect outcome category. This means that even though an engineer is efficiently using his resources, and is being productive with his time, he could still fail to meet organizational goals, and therefore be ineffective.

Engineering Productivity

In a study of productivity measurement for research and development engineers, Schainblatt concluded, "There are no currently used systems for measuring the productivity of scientific and engineering groups without substantial flaws. Nor does the literature on productivity measurement offer encouragement that suitable systems will soon be available" (25:10). If measuring the productivity of research and development (R&D) functions is an underdeveloped field, design engineering may be even more so. The literature contains great quantities of information on productivity, large amounts of information on white collar productivity and some information about professionals. However, outside of the few articles about R&D, there is only occasional mention of engineering. Unfortunately, the information about R&D is not very applicable to AFCE.

By definition most engineers are white collar workers. Thus, most of what was said about white collar workers may apply here also. There are some peculiarities about engineering that make things different. The first difference is a very strong resistance among engineers to performance measurement (18:32). This stems from the nature of the work. Another difference is that the most important measurement for engineering is effectiveness (3). That is to say, meeting organizational goals. Unfortunately, effectiveness can be hard to measure. This is especially true in the design section, where one of the goals is to have a design work well when construction is finished; yet, there may be many years between design and completion of the construction. In light of the difficulty in measuring effectiveness, many managers have settled for something else--often, something like meeting a schedule. This can conflict with the engineers' sense of professional ethics, if they sees this as forcing low quality or possibly unsafe work to be released just to meet a schedule.

If the performance of engineers is truly to be measured, some method of measuring effectiveness needs to be developed first, and maintained as the primary measure. "In this type of system (indirect outcome), the most relevant factors are, at least initially, effectiveness and quality. Only after it has been demonstrated that the correct outputs, of appropriate quality, are being produced should efforts be focused on improvements in productivity and efficiency (34:215)."

Another important area for engineering is simply eliminating unnecessary work. Often a company can get clerks or technicians to do the work, or simply remove the work altogether.

Summary

Productivity improvement is important to the nation. The federal government is no exception to this need. Productivity improvement systems require several things. These requirements are a management focal point, top level support and commitment, a written plan with objectives and goals, a meaningful performance measurement system, use of the plan to hold managers accountable, awareness of the importance of productivity, and ongoing problem identification and solution. A lack in any of these areas will lessen the capabilities of the performance improvement system.

The three most important parts of a productivity improvement program are management commitment, a good measurement system, and follow-through. Without management commitment to change, there will be no system. Follow-through is necessary to retain any improvements, and a good measurement system is vitally important.

The measurement system must be accurate in its assessment of productivity and needs to be trusted by the employees. If the employees don't trust the system, it will probably not succeed. However, the performance measurement system need not be perfect.

There are no easy victories, or instant successes in this business. The improvements in productivity come from the application of good sound management practices. The difference between performance improvement systems and other management methods is that with a measurement system and a focus on performance, people can intelligently work toward the improvement of organizational performance.

Performance improvements come from several sources. First, as people focus on the mission of their organization, they eliminate or place less emphasis on certain tasks. Improved management practices also boost performance. After all of that, people may simply work harder because of the interest given to performance.

The performance of white collar workers is hard to measure, and an engineer's performance is even harder to measure. The things that are the most important in order to successfully measure performance of engineers are effectiveness, quantity, quality, and value.

Performance improvement is a lot of work and comes with risks. To effectively improve performance, management must be committed to change. They must also be willing to commit the effort needed to get and maintain that change.

III. Case Study

Management Environment

Tinker AFB is an Air Logistics Center (ALC) and part of the Air Force Logistics Command (AFLC). As such it is by nature a very large base, with a total population in excess of 25,000 employees (35:c-30). The engineering design section has been broken into two parts. One serves only the ALC maintenance function; the other serves the normal function of a design section, serving the rest of the base. This study pertains only to the design section serving the main base, the more typical design function.

The design section has at least three main functions: design, staff support for management, and engineering support for AFCE maintenance functions. Design is the primary reason for the existence of the design section. Design can be accomplished one of three ways: in-house, Architect-Engineer (AE) contract, or the Army Corps of Engineers (COE). AE designs still require in-house support and inspection. AE contracts take approximately 40 percent of the time that would be used for an in-house design (14). This time is spent mostly on inspection of the design. COE designs take much less time from the in-house force, but still require the completion of design guidance, and several design reviews.

Staff support includes analysis of suggestions for the Air Force suggestion program, occasional reports, and other engineering analysis. The support for the AFCE maintenance function requires more time. This support includes analysis of various system problems, such as air conditioning or electrical distribution problems. All of the utility systems on base require some engineering support.

The design section at Tinker AFB is staffed with approximately 30 engineers and architects to handle these tasks. This staff is divided into groups by specialty, mechanical, electrical, civil and architectual engineering. These groups each have an experienced engineer as the group leader. Each group leader is responsible for the coordination and completion of the work his group accomplishes.

Tinker AFB was also a test site for the WIMs system. This system was installed about 1982 and was specifically designed for AFCE. In addition the design section has just recently received a computer-aided drafting (CAD) system. This system was purchased by AFLC for each of the bases in that command. The training for the CAD system was still being provided. Management had decided to use the training provided in a rather unusual way, by training the engineers first and allowing them to train the draftsmen. This approach seemed to be working quite well (16).

In addition to the command-purchased equipment, the design section tried to make adequate use of any classes available to them. Specifically, they made use of the classes at the Air Force Institute of Technology's School of Civil Engineering and Services.

Research Findings

The system history is very simple. When the design chief took charge six years ago, no formal system was passed on. That is not necessarily to say that the previous design chief did not measure productivity, but that whatever measurement system was used left with him.

Most of the measures were implemented upon the arrival of the new design chief. There was no formal technique used to develop this system; little discussion, outside of required responses, seems to have taken place.

The system was mostly developed by the design chief. There were not any group techniques involved. The system did not need any group consensus, because the measures were only intended to keep the design chief informed. The system has been quite evolutionary in nature, with some measures being added over time, while others have been tried and later dropped.

As in the development, no special effort was made to aid in implementation. Implementation was simply directed by the design chief. The only resistance he had in any implementation was when he decided to use suspense slips to monitor all the responses required from his section. Each piece of correspondence that requires any response at all is recorded in this system. That way the design chief is made aware of anything that does not get done on time.

System Presentation

The section under investigation was chosen because of a computer program they use that has some performance measures built into it. This program's real function is to produce a design schedule. This computer program forms the backbone of the performance measurement and control system, but there are other measures used. However, there is not a uniform use or understanding of those measures, or of performance in general. The method of performance measurement used is not really a system. It is more of a collection of independent measures that function, and are used independently.

The section under study measures effectiveness, quality, productivity, and efficiency. Each of these areas will be described here. Functional definitions as well as methods of measurement will be given. A brief overview is shown below.

Effectiveness

Completion of design schedule

Negative feedback

Backlog of work orders and cost estimates

Efficiency

Design schedule program--Performance against schedule

Productivity

Time sheets

Percentage of time spent on design

Quality/Value

Inspection of work

Effectiveness. Effectiveness was pointed out by the literature review as the single most important measure for engineers. Effectiveness is a very difficult thing to functionally define. The standard definition is meeting organizational goals. The goal of the design chief was to satisfy the chain of command. There are two main priorities for the design section (14). The first priority is to design projects. The required quantity of projects is variable and set by the major command. This is done by somehow combining the information in the Civil Engineering Contract Reporting System (CECORS) with the command funding ability for the year. This gives an annual target of total estimated contract cost. If that amount of design is done, the organization met that goal. That goal can be exceeded if additional designs are completed to take advantage of any extra money that is made available at the end of the year.

The second priority is to "stay out of trouble." This is not unusual in a military organization, and probably normal in many other organizations. This goal is to do everything else required, well enough that the commander does not have problems brought to his attention (14). These things may be trivial or important, but they are all secondary to design. Although the second goal is hardly what the literature would recommend, it is functional and agreed upon by the squadron's management (14;32).

The squadron commander measured the effectiveness of the design section by its ability to meet command design targets and take advantage of year-end money. Secondly, he saw them as effective because there were not any negative reports about the design section. He did not formally track any of this information (32).

The squadron commander was quite satisfied with the performance of the design section. One other factor that particularly pleased him was the ability of the design section to take in stride changes to the design schedule (32). This could be attributed to three things: a flexible attitude, good management, and the computer program to develop design schedules.

The method of measuring effectiveness is not really what was expected. However, it does work for the design section chief, and it provides the small amount of refinement he needs to keep control.

The one major item used to assure effectiveness is the design schedule. This is monitored on a weekly basis. The design schedule is watched closely by the chief of design and all of the group leaders, and is the only item reported outside of the section.

The other part of the effectiveness measurement system is to track work coming and going. All items that come into the section, that require any response, are given a suspense slip. Those suspenses are tracked to assure that the work is eventually completed. In addition, work orders and cost analyses that require design input are tracked both in quantity and timeliness. High priority work orders or cost estimates are given a management push; otherwise, these things are pushed as necessary to keep from developing too much of a backlog (15).

Efficiency. Efficiency is measured by the computerized design schedule program. This is done by simply comparing the estimated hours for design with the actual hours used to design a project (21). This is done at various stages of design. It is monitored on approximately a weekly basis by the chief of design and the group leaders (14). There is one admitted weakness of this method of measure and that is estimating the hours of design time (14; 20). This is done by two methods. First, an engineer estimates how long it will take, then that estimate is compared to the six percent fee that an A/E firm would receive. The AE fee is calculated by taking six percent of the estimated contract price, dividing by two to separate labor and overhead, and then dividing by an average of $25 an hour. This gives a rough estimate of the number of hours required by an AE to do the same project. These two figures are compared, then one is chosen and loaded in the design schedule (14). Because of the weakness in the estimate, it is used as a guideline more than an absolute. This system gives averages and allows the section chief to keep the design schedule on time. The aggregated figures on how an engineer does are used for information to back up his performance rating.

Productivity. Productivity is measured with three methods. First, a time sheet is filled out, on a daily basis by each engineer. The time sheet explains what the engineer did with his time. Some amount of time is expected to be spent on non-design items, but the percentages spent in different areas are monitored.

The second method is the goal of having 40 percent of the time spent on design. This is tracked individually, by group and for the section as a whole. The goal is not to exceed 40 percent but to stay near 40 percent. This goal was thought to be in the Air Force regulation somewhere, but no one was sure where. The researcher was unable to locate it.

Quality. The chief of design was concerned by his inability to measure quality. He was considering getting feedback from the base working group panel, which is a locally run organization that has representatives from each of the organizations on base. He did realize that the kind of feedback he would receive was not going to be completely accurate and would probably be negatively skewed. But this weak information was perceived as being better than no information at all.

The interesting observation about quality is that the group leaders did not have a problem defining it, nor did they have a problem knowing if quality was there. The group leader's job includes checking each of the projects an engineer does, at various levels of completion. When the work is checked, the group leader assures himself that adequate quality is there. If a the project is found to be lacking, then the project is either sent back or notes are made as to what needs to be changed for the next review (16; 7). While it is true that there is no written standard for quality, each group leader had firmly in mind what quality meant to him and checked for it. This measure was not quantified in any way. The group leaders simply did not release a project until the necessary quality was there. The researcher believes that this method will work fine as long as the group leaders share the organizational views of quality and value. Additionally the group leaders must be capable of recognizing quality and providing assistance when necessary, to assure quality. This method is arbitrary, but usable.

An additional method that had been tried and abandoned was tracking change orders. This practice was largely abandoned after a short time because there were so few change orders, and most were caused by other than quality issues. This alone would seem to indicate that adequate quality was included in the designs.

Research Sequence

Initially, contact was made with a design section with the intention of both implementation and study of a measurement system. Instead, the initial contacts uncovered a system in the process of being implemented, and a second section (at Tinker AFB) which was already using the same program.

The first interviews were somewhat hindered by vocabulary barriers. The chiefs of design have had little formal training on performance measurement, and they have little understanding of the in-depth technical issues. This led to several false starts due to different definitions of the same words.

The first plan for study was to include both of the design sections previously discussed. It soon became apparent that the section currently implementing the measurement system would not be ready in time to complete this research. That forced the researcher to focus on the section at Tinker AFB, which had been using the program for several years.

The case study was conducted by traveling to Tinker AFB to conduct interviews with the appropriate people, using a semi-structured interview format. Telephone follow-ups were also conducted. The first day, the chief of design was interviewed along with one of his more involved group leaders. Then some revisions were made to the interview format. The second day, the remaining available group leaders were interviewed. The last day, the squadron commander and the industrial engineer were interviewed.

Productivity Measurement System Use

The system was developed to aid the chief of design in monitoring and controlling the section, and that is all it is used for. The system is only used by the chief of design and the group leaders. There is no effort at improvement of performance, only on keeping performance above set limits, and meeting set goals. In addition, the system is not used directly for performance appraisal. Performance measures of each engineer are taken into account for appraisal, but not used directly.

The performance measures used by the design section are not thought of as a system, although they are used in a systematic way by the design chief to control the section. The system represents more of a collection of independent measures, each used in a slightly different way to control the various aspects of performance.

Validity

The investigation of validity did, as mentioned in the methodology, include technical validity, organizational validity and use.

Technical validity requires the system to accurately measure the areas it purports to measure. The system does measure the right things, and in a reasonably correct manner. However, accuracy is questionable. The measures of effectiveness and quality are subjective, and the measure of efficiency is of only questionable accuracy. However, because of the way the system is used, the accuracy required is also low. Therefore, even though the system is not highly accurate, it does meet the needs the organization imposed upon it. The system seems to assure reasonable levels of organizational performance. However, the measurements that are used are not highly refined.

Technical validity of the organizational model is based on ease of measurement, selection of appropriate variables, reliability and validity of the underlying variables. The validity of this model appears to be adequate. The variables measured reflect the recommendations of the literature and the method of measuring each variable is simple and straight forward. In addition the system is easy to use and very well incorporated in the management structure. However, the efficiency and quality measures must be viewed as having only questionable validity.

Organizational validity is a measure of how well the system is accepted by the organization. In the case of this system, acceptance by the user is rather a mute point. The system is used mostly for control, not for official reports; therefore, no real threat is imposed. With the real purpose of the system being control, the system is not visible to anyone other than management.

What visibility does exist is accepted simply as necessary management control.

The system has been effectively used to do what the design chief wants. This is not, nor was it intended to be, a system of measures designed to bring systematic improvement to performance. Rather, the system was designed to keep performance in bounds. Specifically, the system is in existence only to meet the management need to provide control, which it does well enough to satisfy management's expectations.

Productivity Improvement

Some of the biggest possibilities for productivity improvement have not been used here. In the literature the two greatest areas for productivity improvement come from identifying and eliminating unnecessary work, and changing policies and procedures that hinder productivity. The section under study has not visibly done either.

As far as changing policies and procedures, the section seems to have no special effort to do this. Part of the reason for this is undoubtedly due to the typical perception that it would take a lot of time and probably not be successful anyway. Instead, the section here has worked within the confines of the broader organizational system.

When asked what he had done to improve performance, the chief of design mentioned sending himself and one group leader to available management classes. Unfortunately the other group leaders were not allowed to attend, because of a rule in the base personnel system that required them to be designated as supervisors. The chief of design expressed his frustration at this problem, and his inability to get anything done about it (14).

Summary

The model of performance that is used by the section under study does provide them some level of performance measurement. The problem with their system is that it uses mostly subjective measures and little actual quantifiable data. Although this system could be improved, there is presently little desire to do that. The system in use fulfilled the information needs required to meet the management function of controlling the organization. The section under study has no performance improvement system, only a management control system. Although the two are very similar in appearance, they are different in function.

IV. Conclusions and Recommendations

Measurement System

The measurement system used by the design section at Tinker AFB meets the basic requirements necessary to be a performance measurement system. However, it lacks the precision required to differentiate between small differences in performance. The reason for this appears to be a difference in purpose. The researcher was expecting a performance measurement system; instead, the purpose of the system seems to be management control. The similarities between the two types of systems exist because both serve one of the basic managerial functions of control, only the former adds to that function the ability to closely measure performance with the expressed purpose of improvement.

The performance improvement aspect of the system was almost entirely missing. The main reasons for this seem to be a perceived lack of importance and ability to change regulatory hindrances. The researcher found no working knowledge of the executive order that directs productivity improvement. The Air Force command structure may have knowledge of this executive order, and may have indeed done something about it, but there is no evidence of this knowledge at the squadron level. Additionally there appears to be little perceived benefit from productivity improvement.

In the literature review, it was shown that the two major sources of improvement in performance came from changing rules that hinder the worker and eliminating unnecessary work. The perception of those interviewed seemed to be that they could not change either the work they were required to do, or the rules governing them.

Seldom can a squadron level section chief decide that something is unimportant and should not be done. Instead, what the design chief had done was shift the emphasis so that design was given more emphasis than other, less important, work. Most of the measures taken were of the design function. The only way of monitoring other work was with a suspense slip. The suspense slip served only to assure timeliness and completion, both of which are necessary for effectiveness. The chief of design at Tinker AFB seemed to have little interest in trying to change rules and regulations that hinder the performance of the section. One reason for this is shown in the literature review. In the literature review it was shown that one of the side benefits to a structured approach at developing a performance measurement system was identifying regulatory hindrances. Not having gone through such an approach, it is reasonable to expect no such outcome would develop.

Simply enough, the hindrances are part of the organizational structure, and generally have been there long enough to be ignored as such.

The models used by past researchers tried to incorporate most of the other work done by the design section (suggestions, work orders, reports, and Prime Base Emergency Engineering Force requirements among other things) into the measurement system. This design section simply strived to assure other work was finished in a timely manner. This method seems to work well for the design section at Tinker AFB.

One possible remedy to the perception of not being able to change the system would be the implementation of the model installation program (MIP). The researcher has seen how MIP can change this perception rather quickly. In the researcher's opinion MIP still lacks the formal method of identifying problems. Instead, it takes on the character of what would normally be follow-up. One at a time as workers encounter problems, those problems surface in the MIP system and are remedied.

In general, the measurement system developed by Tinker AFB's design section is similar to what the literature review recommends. It incorporates the same measures: effectiveness, performance, efficiency, and some measure of quality. The system is also simple and understandable.

However, the system lacks the ability to quantify several of the performance measures.

Comparisons

Comparing the performance measurement system with the information provided in the literature review shows both similarities and differences. The similarities are in the things being measured. The system observed does measure each of the areas suggested as most important in the literature review: effectiveness, productivity, efficiency, and quality. The basic structure is provided in that the most important areas of performance are measured.

Effectiveness was stressed as being most important to engineering performance measurement. The section under study has a method of determining effectiveness that works well, and satisfies management.

There are differences in the system and the literature review. The differences nearly all stem from a single source: purpose. The purpose of the system under investigation was to provide the information necessary for management to control the organization, more specifically to meet the design schedule. The purpose in the literature review was always to improve performance, and always started with a perceived need to improve performance. During the research, no such perceived need was observed.

It is this perceived difference in purpose that caused the most noticeable lack in the system under study. Because the emphasis was on maintenance rather than improvement of performance, there were no devices in place to improve performance. No management action teams or study groups were in place. The only real effort to improve performance was in improving equipment and quality of the office space, and sending the engineers to schools and seminars to improve their skills. These schools, especially AFIT short courses, have been very effective in improving the efficiency of the engineers (16).

The second perceived weakness in the system they use may just be one of preference. This researcher would prefer a more quantifiable system, to allow more precise measurement, which would allow management to more accurately assess small changes in performance. The system under use in the section here really is not quantifiable, but instead provides bounds that the section can monitor. Although this would not lend itself well to fine tuning performance, it does adequately fill management's present needs.

General Conclusions

This research lead down many dark alleys, and a great many things were learned in areas that were not intended to be studied. These extraneous lessons fall into three broad areas. First, there is a serious lack of communication in the United States Air Force about performance and productivity. Second, most of the past research focus on measurement with little emphasis on actually improving performance. A simple model such as the one used at Tinker AFB may provide the accuracy necessary to start working on improvement. And third, there is little incentive to improve performance, and often the opposite exists, which is motivation not to improve.

The researcher was first confronted in the literature review with the lack of common definitions for performance and productivity. The two terms are often used interchangeably. In the Air Force, these terms are just as confused. The researcher found several times at the beginning of this research that conversations were nearly meaningless because of this lack of common definition.

To perpetuate this lack of common definition, there is little communication about the subject in the Air Force. The various sources of continuing education offered do not include the study of performance improvement or measurement. There is also no easy way for one squadron to pass on information to the rest of the Air Force. Part of the reason for this is that there is not any publication specifically for Air Force Civil Engineering at this time. All of this lack of communication causes the next problem.

There is not any working knowledge of available help. The only resources known to any of the people who were interviewed, are AFIT short courses and various management classes available locally. No one had heard of MGEEM, and knowledge of any other performance improvement system was very limited.

The second area of unexpected learning came mostly from the literature review. Sheehy said that the higher in the structure you go, the greater the affect of change (27:144) His observation is unquestionable, yet there is a second similar observation. The farther down the chain of command one goes, the less the perception of ability to implement change. This has been partially overcome by programs like MIP, but only in specific locations. Unfortunately, it appears that most of the Air Force research in the past has been at the squadron level, which is where the ability to implement change appears to be lowest.

A confounding factor in the literature is that most of it is about business. The literature about the public sector is usually of cities or small federal government agencies. With these organizations there are not the many layers of command that occur between the squadron level of the Air Force and top management. Some of that top management is completely out of the Air Force, such as Congress, which often does not share the same goals and concerns. If real performance improvement is to come to the Air Force, it must come from top management. This includes all of the major commands and the Air Force Engineering and Services Center, as well as necessary congressional support. It appears at present that some interest exists at the higher levels, but it is badly diluted by the time it gets to the squadron level.

One of the things the researcher observed was the way major command performance improvement programs work. During the case study, the researcher was told of a new program from the major command for quality improvement. The perception of the program was that it was imposed and would be of little or no help. This was followed by the perception that this, like other similar programs, would go away with the next change of command ceremony (14). Under these circumstances, even a good program is likely to fail.

Finally, there is little perceived need to improve performance, and probably less perceived ability. However, there is a perceived need to measure and control performance, and that opens a door for future improvement. In the researcher's opinion, part of the reason for this perceived lack of need is that there is little incentive to improve performance. There is a common perception that performance improvement can lead to decreased manpower and budgets (19:152). Capital improvements appear especially prone to causing manpower losses. This causes some managers to look at real attempts at performance improvement as risky. The researcher saw another problem faced early in the MIP program. The problem was that of who gets the dollars saved. If the organization that is saving the money gets to use even a portion of that money for other things, it provides incentive to improve. This ability to reprogram saving is not usually the case outside of the MIP program.

The personnel system may also act as a hindrance, because of the excessive amount of control faced by management. In the literature review, it was shown that first line managers should have the authority to hire and fire employees. Management does not always perceive this to be the case. Even though hiring is supposedly a management function, management is told when they can and cannot hire, based on strict manpower standards, and the applicants are screened. Additionally, the researcher does not believe that managers perceive a real ability to fire an employee. Many managers also complain about how restricted they are in the ability to use pay as an incentive. Not only can they not give bonuses, but they cannot give pay increases based on performance, except in very few circumstances (7).

Areas For Further Research

One of the problems with this system was with the efficiency measure which used an estimate of the design time needed to complete a project. A program has been developed to estimate design time and has been used at Keesler AFB. This program needs to be examined and its accuracy verified. The addition of the estimating program to Tinker AFB's existing design schedule program would be very valuable. A more valuable area for further research would be to focus on performance improvement over performance measurement.

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ABSTRACT

The design section is responsible for designing projects for completion by contract, overseeing designs done by architect-engineer firms or the Army Corps of Engineers (COE). The impact a design section has on an Air Force base is enormous. The programmed budget for construction for 1987 was over $3 billion, or about 15 percent of the Air Force operations and maintenance budget.

Performance is important in any organization with this large of an impact. That performance should constantly be improved. Before performance can be improved it must be accurately measured. The literature available suggests that to accurately measure the performance of engineers, one must first identify key dimensions of performance which, when accomplished, will assure effectiveness. After effectiveness has been assured, then efficiency, productivity and quality need to be measured. Together these four things give a picture of performance.

A case study of an Air Force Civil Engineering design section was done with the purpose of documenting the system used for performance measurement. The system used measured effectiveness, performance against schedule, efficiency and productivity. Some capability of assuring quality was also built into the management system.

The system that is used by the section under study does provide a limited capability to measure performance. However, this system uses mostly subjective measures and little actual quantifiable data. This is a weakness if fine differences in performance need to be measured, as would be the case for a performance improvement system.